

# Plant Propagation

SUMMARY OF INSTRUCTIONAL ACTIVITIES



## 🕒 Return of the Wild! - page 11

- Students play Return of the Wild! game and learn about the benefits of biodiversity.

## 🕒 Plant Propagation - page 17

- Students participate in a variety of nursery operations which may include:
  - propagating plants sexually and/or asexually
  - transplanting seedlings
  - maintaining pots and leach tubes
  - cleaning seeds
  - planting or weeding in the demonstration garden

Students learn about plants and nursery operations:

- use microscopes to identify and study plant pathogens
- calculate the number of plants to put in a restoration area
- calculate the number of plants that nursery staff must propagate
- examine and draw characteristics of plants in the demonstration garden
- write a short paragraph describing how sexual and asexual propagation impact diversity (integrated assessment)

## 🕒 Seed Experiments - page 23

- Students will:
  - germinate seeds under varying conditions
  - compare plant growth and health
  - introduce further variations on plant treatment, including changing soil quality
  - test soil pH, nitrogen, phosphorous, and potassium levels
  - analyze data gathered, create lists of most favorable and least favorable conditions for plant viability, and graph some aspect of their experiment results (integrated assessment)
  - write a paragraph relating genetic diversity to species viability under changing environmental conditions

# Standards

## Plant Propagation

### **SFUSD Science Content Standard 12: Diversity**

Students understand that the variation of organisms within a species increases the likelihood that at least some of the members of the species will survive under changed environmental conditions, and that the great diversity in species increases the chance that at least some living things will survive in the face of large changes in the environment.

- ▶ *Performance Standard:* Students can explain the relationship of diversity to species and ecosystem survival. Students can name several ways in which the National Park Service attempts to increase the diversity within the natural areas under its stewardship.

### **SFUSD Math Content Standard 3: Function and Algebra**

Students demonstrate their knowledge of basic skills, conceptual understanding, and problem solving in function and algebra.

- ▶ *Performance Standard:* Students can write appropriate algebraic equations to answer questions about propagation needs at the native plant nursery (based on SFUSD Performance Standard 3.2.6).

### **National Life Skills Standard: Contributes to the overall effort of a group**

Students demonstrate respect for others in the group, take initiative when needed, engage in active listening, and contribute to the development of a supportive climate in group.

- ▶ *Performance Standard:* Students can contribute effectively to their groups during park and classroom group activities.

# Plant Propagation

## **GOLDEN GATE NATIONAL RECREATION AREA NATIVE PLANT NURSERIES**

Golden Gate National Recreation Area (GGNRA) has six nurseries specializing in the propagation of plants indigenous to the San Francisco Bay Area. Plants raised in the nurseries generally replace invasive exotic species removed from habitat restoration sites throughout the park. NPS staff propagate approximately 150 different plant species—from grasses to trees—in these nurseries. This large number reflects the wide diversity of the park's ecosystems, ranging from sand dunes to coastal chaparral to redwood forests.

The Presidio Native Plant Nursery is the largest of the six nurseries. Its structures and facilities are typical of those found in many commercial plant nurseries. The three greenhouses are equipped with automatic irrigation systems and motorized fans to control humidity and temperature. Several shade houses protect the young, delicate seedlings from the harsh rays of the sun while they are hardening off. These structures and their fittings control the principal environmental conditions that influence plant growth: light, water, temperature, carbon dioxide, and oxygen. This optimizes seed germination and helps ensure high survival rates in the nursery. It allows nursery staff to remove less seed from the wild than they would need to without these structures.

## **GENETIC DIVERSITY**

A high level of genetic diversity allows some plants to survive after being planted into the restoration site even if it is a dry year or a wet season, or if animals nibble on the seedlings in April. Genetic diversity in GGNRA is maintained by collecting seeds at different times, by transplanting seedlings that have sprouted both early and late, and by planting both small and robust plants. Native plants are propagated carefully because once they are planted out in their native environment, they are left to nature's whim, with no human intervention.

### **What is Plant Propagation?**

Plant propagation is the multiplication of plants by either sexual or asexual methods. Sexual propagation involves seeds, while asexual propagation is done using cuttings, layering, division, or grafting. At the Native Plant Nursery, staff prefer to propagate plants sexually, using seeds collected in the park. This results in genetically diverse plants, which are more likely to succeed in the face of disease or variations

in environmental conditions. Asexual propagation is used when there is not enough seed available for collection or when propagating plants that reproduce asexually in the wild. The drawback to asexual propagation is that all the new plants are clones of the mother plant, and therefore have no genetic diversity.

### **Asexual Propagation:Vegetative Methods**

Using runners, stem cuttings, and crown divisions are common methods of vegetative propagation in nurseries and at home. All vegetative propagation methods produce plants with genotypes that are identical to the mother plant and, therefore, limit genetic diversity. However, such methods have the advantage of producing a large plant in a short period of time.

#### **Runners**

A runner is a specialized stem that develops from the axil of a leaf at the crown of a plant. It grows horizontally along the ground and forms a new plant at one of the nodes. Two plants in the park that produce runners are the beach strawberry (*Fragaria chiloensis*) and yerba buena (*Satureja douglasii*).

Vegetative propagation by runners involves removing a runner from the mother plant, dividing it into sections, and planting these sections in potting soil. Within two or three weeks, adventitious roots develop at intervals (every other node in the case of the beach strawberry) along the runner to produce "daughter" plants, which can then be transplanted into pots.

### **Sexual Propagation:**

Seeds are the main method by which plants reproduce themselves in nature. Because seeds from different species of plants vary greatly in size, shape, and structure, plants can often be identified by looking at the seeds they produce. Regardless of their size, shape, or structure, all seeds have three basic parts -- the embryo, food storage tissues, and seed covering.

#### **Embryo**

The embryo is a new plant formed from the union between a male and female gamete during fertilization. It consists of an embryo axis that has a growing point at both ends—one develops into the shoot and one develops into the root—and one or more seed leaves (cotyledons) attached to the embryo axis. Plants can be classified according to the number of cotyledons they have. For example, monocotyledonous plants (grasses, corn, and bulbous plants) have one cotyledon while dicotyledons, or dicots, (all broadleaf plants, lupines and most of the herbaceous and woody shrubs in the Presidio) have two cotyledons. Dicots and monocots are both examples of angiosperms (plants whose seeds are borne within a mature ovary, or fruit). Gymnosperms, such as conifers, are plants whose seeds are not enclosed in an ovary.

### Food storage tissues

The successful germination of a seed and the emergence above ground of the resulting seedling depend on energy produced from complex storage products (carbohydrates, fats, oils, and proteins) laid down in the seed by the mother plant.

### Seed covering

Nearly all seeds are surrounded by one or two seed coats (testa) which help to protect the embryo from damage. The outer seed coat is usually dry and hard.

### Seed Transport

Because plants are unable to move from one place to another, they depend on wind, water, and animals to distribute their seeds. Plants have adapted special characteristics to help their seeds disperse. For example, wind-dispersed seeds tend to be very small and light and have physical features that enable them to be carried by air currents; coyote bush (*Baccharis pilularis*) and mock heather (*Ericameria ericoides*) have feathery "parachutes" (the botanical name for this parachute is pappus). Some seeds have small claw-like protrusions on their seed coat that enable them to stick to the hide of an animal such as a raccoon or deer. Other seeds are borne in fruits or berries that are eaten by birds or other animals. The seeds inside these berries usually have tough coats that cannot be completely digested by the animal. Consequently, the whole seed passes through the animal and is dispersed wherever the animal relieves itself.

# Propagación de Plantas

## LOS VIVEROS DEL ÁREA NACIONAL RECREATIVA GOLDEN GATE

El Área Nacional Recreativa Golden Gate tiene seis viveros que se especializan en la propagación de plantas nativas del Área de la Bahía de San Francisco. Las plantas cultivadas en los viveros por lo general sustituyen las especies exóticas invasoras que han sido removidas de hábitats bajo restauración de todo el parque. El Servicio Nacional de Parques (NPS) propaga aproximadamente 150 especies diferentes de plantas – hierbas y árboles – en estos viveros. Este elevado número refleja la amplia variedad de ecosistemas del parque, que incluyen dunas arenosas, chaparrales costeros (maleza impenetrable de arbustos o pequeños árboles) y bosques de redwoods (coníferas).

El Vivero de Plantas Nativas del Presidio es el mayor de los seis viveros. Sus estructuras e instalaciones son similares a las de muchos viveros comerciales de plantas. Los tres invernaderos están equipados con sistemas automáticos de riego y abanicos eléctricos para controlar la humedad y la temperatura. Varias casas de sombra protegen a las jóvenes y delicadas semillas de los fuertes rayos del sol mientras se fortalecen. Estas estructuras y sus artefactos controlan las condiciones ambientales principales que influyen en el crecimiento de las plantas: luz, agua, temperatura, bióxido de carbono y oxígeno. Esto hace más posible la germinación de las semillas y ayuda a garantizar un promedio alto de supervivencia en el vivero. Esto a su vez le permite al personal del vivero remover menos semillas del ambiente natural, de las que tendrían que remover si no existieran dichas estructuras.

## DIVERSIDAD GENÉTICA

Una amplia diversidad genética le permite a algunas plantas sobrevivir luego de ser sembradas en el lugar de restauración, tanto en años de sequía como en temporadas lluviosas y aun cuando los animales piquen o roan las semillas en abril. La diversidad genética en el Área Nacional Recreativa Golden Gate se mantiene recogiendo semillas en diferentes épocas, transplantando semillas que germinan lo mismo tarde que temprano y sembrando plantas pequeñas pero robustas. Las plantas nativas son propagadas cuidadosamente porque una vez han sido sembradas en su ambiente nativo, se dejan a merced de la naturaleza sin intervención humana.

### ¿Qué es propagación de plantas?

Propagación de plantas es la multiplicación de plantas por medios sexuales y asexuales. La propagación sexual se realiza con semillas, mientras que la propagación

asexual se realiza cortando, replantando, dividiendo tallos o mediante injertos. En el vivero de plantas nativas el personal prefiere la propagación sexual usando semillas recogidas en el parque. Esto resulta en plantas con una diversidad genética que tienen más probabilidades de crecer y vencer las enfermedades y los cambios del clima. La propagación asexual se utiliza cuando no es posible recoger suficientes semillas o cuando son plantas silvestres que se reproducen asexualmente. La desventaja de la propagación asexual es que todas las plantas nuevas son copias de la planta madre y no tienen diversidad genética.

### **Propagación Asexual: Métodos Vegetativos**

Los estolones (retoño rastrero), trozos de tallos y coronas son métodos comunes de propagación vegetativa en viveros y hogares. Todos los métodos de propagación vegetativa producen plantas con genotipos o estructuras genéticas idénticas a las de la planta madre y, por lo tanto, limitan la diversidad genética. Sin embargo, estos métodos tienen la ventaja de que producen una planta grande en un período de tiempo corto.

#### Estolones (vástagos rastreros)

Un estolón es un tallo especializado que se desarrolla de la axila en la corona de una planta. Crece horizontalmente echado en el suelo y forma una planta nueva en cada uno de sus nódulos. En el parque hay dos plantas que producen estolones: la fresa playera o "beach strawberry" (*fragaria chiloensis*) y la yerbabuena o menta (*satureja douglasii*).

La propagación vegetativa por medio de estolones consiste en remover un pedazo de la planta madre, dividirlo en secciones y sembrar dichas secciones en macetas con tierra. En dos o tres semanas se desarrollarán raíces adventicias a intervalos a lo largo del estolón (cada otro nódulo en el caso de la fresa playera) para producir "hijos" que pueden entonces ser transplantados a tiestos.

### **Semillas**

Las semillas son el método principal por el cual la plantas se reproducen en la naturaleza. Debido a que las semillas de diferentes especies de plantas varían mucho en tamaño, forma y estructura, a menudo las plantas pueden ser identificadas mirando las semillas que producen. Las semillas tienen tres partes básicas, no importa su tamaño, forma o estructura: el embrión, tejido para almacenar alimento y una cubierta o capa.

#### Embrión

El embrión es una planta nueva que se crea de la unión de gametos (células reproductoras) masculinos y femeninos durante la fertilización. Consiste de un eje embrionario que crece en ambos extremos – uno se desarrolla hasta formar un renuevo o

tallo nuevo y el otro se convierte en la raíz – con cotiledones (una o más hojas) de la semilla pegadas al eje del embrión. Las plantas pueden ser catalogadas de acuerdo al número de hojitas o cotiledones que poseen. Por ejemplo, las plantas monocotiledóneas (hierbas, maíz y plantas con bulbos) tiene un cotiledón, mientras que las dicotiledóneas (todas las plantas de hojas anchas, lupinos, la mayoría de las herbáceas y arbustos leñosos del Presidio) tienen dos cotiledones. Tanto las dicotiledóneas como las monocotiledóneas son tipos de angiospermas (plantas cuyas semillas están alojadas en un ovario maduro o fruta). Las gimnospermas son plantas cuyas semillas no están dentro de un ovario; las coníferas (como el redwood) son gimnospermas.

#### Tejido Almacenador de Alimento

La germinación exitosa de una semilla y el retoño que surge del terreno depende de la energía producida del almacenaje de productos complejos (carbohidratos, grasas, aceites y proteínas) depositados en la semilla por la planta madre.

#### Cubierta de la Semilla

Casi todas las semillas están cubiertas de una o dos capas (testa) que ayudan a proteger el embrión contra daños. La capa exterior de la semilla usualmente es seca y dura.

#### Transporte de la Semilla

Debido a que las plantas no pueden moverse de un lugar a otro, éstas dependen del viento, del agua, y de los animales para distribuir sus semillas. Las plantas han adoptado características especiales para ayudar a dispersar sus semillas. Por ejemplo, las semillas dispersadas por el viento tienden a ser muy pequeñas y livianas y a tener características físicas que permiten que sean llevadas por corrientes de aire: el arbusto Coyote Bush (*Baccharis pilularis*) y el matorral Mock Heather (*ericameria ericoides*) tienen "paracaídas" plumados (el nombre botánico de este paracaídas es pappus). Algunas semillas tienen protuberancias como diminutos ganchos en la cubierta de sus semillas que les permite pegarse de la piel de un animal como un mapache o un venado. Otras semillas son alojadas en frutas o bayas que consumen los pájaros y otros animales. Las semillas dentro de estas bayas a menudo tienen cubiertas duras que no pueden ser completamente digeridas por el animal. Como resultado, la semilla pasa completa por el animal y se dispersa en cualquier lugar que el animal deposite su excremento.

# 植物繁殖

## 金門國家康樂區 本地植物苗圃

金門國家康樂區 (GGNRA) 內有六個苗圃，專門用來繁殖舊金山灣區的本地植物。這些苗圃所培育的植物是用來取代那些已從公園的重建棲息區中除去的侵佔性外來品種。國家公園服務部的員工在這些苗圃中培育的本地植物，大約有一百五十多個品種--從青草到樹木都有。這個數字反映出公園內的生態系統極為多元，從沙丘、海岸灌木叢到紅木林不等。

Presidio 的本地植物苗圃是這六個苗圃中最大的，苗圃的結構和設施和很多商業苗圃所見的類似。三個溫室都備有自動化灌溉系統和馬達風扇，可以控制溫度和濕度。幾個有遮蔭的房間，在嬌嫩的幼苗進行耐寒的階段時，可以保護植物不會直接被太陽曬到。這些結構均提供影響植物生長的最佳環境：光線、水、溫度、二氧化碳和氧氣，使我們能達到最高的發芽率。有了這些結構之後，苗圃員工就可以從野外移除較少的種籽。

## 遺傳多元化

因為高度的遺傳多元化，使得一些植物即使遇到乾旱或是濕季，或是苗木在四月時被動物啃過，仍能在植入生態重建地之後存活。GGNRA 利用在不同的時間收集種籽，移植早或晚發芽的苗木，同時種植細小和粗壯植物等各種方式，來維護遺傳多元化。我們小心繁殖本地植物，因為它們一旦在其自然棲息環境中立足生根，等於就要自求多福，人類不會再介入。

## 什麼是植物繁殖？

植物繁殖是指以有性或無性方式增生植物的過程。有性繁殖要用種籽，而無性繁殖則要用插枝、壓條、分株或嫁接等方式。本地植物苗圃員工喜歡用從公園收集回來的種籽進行有性的植物繁殖。這樣一來，雖然面對病害或生長環境條件的變化，還是可以成功地培育出遺傳多元化的植物。如收集的種籽不夠，或在野生地進行植物繁殖，就會用無性繁殖。缺點是所有的新植物都是母植物的複製體，因此沒有遺傳多元化的特性。

## 無性繁殖：營養生殖方式

苗圃和住家經常使用長匍莖、插枝和花冠分株等的營養生殖方式。所有的營養生殖方式都

會產生基因型與母植物完全相同的植物，因此遺傳多元化有限。不過，此種方式的優點是可在短期之內生成一棵大型植物。

#### 長匍莖

長匍莖是一種特別的莖，此莖是由植物花冠上的葉腋生成。它會沿著地面水平生長，可在其中一個節點形成一株新的植物。國家公園內的海邊草莓 (*Fragaria chiloensis*) 和 yerba buena (*Satureja douglasii*) 兩種植物都會生出長匍莖。

用長匍莖進行營養生殖時，要先從母植物取下一條長匍莖，把它分段種入盆中的泥土。兩到三週以後，中段（海邊草莓會每隔一個節點）的地方會沿著長匍莖長出偶生根，形成“子”植物，然後可以移植到盆中。

#### 有性繁殖：

自然界植物主要是靠著種籽自行生殖的。因為不同植物品質的種籽在顆粒、外型 and 構造彼此差異很大，所以植物所產生的種籽通常可用來辨識不同的植物。無論顆粒大小、外型或構造如何，所有的種籽都有三個基本部份——就是胚胎、食物儲藏組織和種皮。

#### 胚胎

胚胎是在發芽時期一個雄性和雌性配子結合所形成的一株新的植物。它包括一個胚胎主莖，兩端各有一個生長點——一端發育成芽，另一端發育成根——上面還連著一到多個子葉 (cotyledons)。植物可以根據它們的子葉數加以分類。舉例來說，單子葉植物 *monocotyledonous* (草、玉米和球莖類植物) 有一個子葉，而雙子葉植物 (*dicotyledons* 或 *dicots*，所有闊葉木、羽扇豆和大多數草本植物和 *Presidio* 的灌木叢) 則有兩個子葉。雙子葉和單子葉是兩個被子植物的例子 (這種植物的種籽都長在成熟的子房或果實裡)。裸子植物，例如針葉樹，它們的種籽都長在成熟子房或果實的外面。

#### 食物儲藏組織

一顆種籽能否成功發芽，並伸出地面長成幼苗，全看母植物傳給種籽的綜合儲存生成物 (碳水化合物、脂肪、油脂和蛋白質) 所產生的能量而定。

#### 種皮

幾乎所有的種籽都由一或兩層種皮 (*testa*) 包裹，可以保護胚胎不受傷害。種皮的外層通常又乾又硬。

### 傳播種籽

因為植物無法移動位置，所以就有賴於風、水和動物來傳播它們的種籽。植物具有各種特徵來幫助它們傳播種籽。例如，藉風力散播的種籽通常都比較輕巧細小，它們這種特徵便於氣流將它們帶到別處；大草原灌木 (*Baccharis pilularis*) 和掃帚樹 (*Ericameria ericoides*) 有羽狀的「柔毛」(“parachute” 的學名是「柔毛」“pappus”)。有些種籽皮上面有像爪子一樣的小隆起物，可以黏在像浣熊或鹿這類動物的毛皮上。其他的種籽都包在果實或莓果裡，鳥或其他動物會吃這些果實。這些莓果內的種籽皮通常都很堅硬，動物無法完全消化掉。因此，整顆種籽就會通過動物的消化系統，隨著動物的排泄物散播在各處！

## Return of the Wild!

### **SUMMARY**

Return of the Wild! introduces students to the importance of maintaining biological diversity when propagating plants for habitat restoration projects. While playing Return of the Wild! students will discover that they score highest by collecting early-season, mid-season, and late-season germinators of a species. A post-game discussion helps students understand why this variation is essential. Return of the Wild! also familiarizes students with some of the more prominent species that grow in GGNRA. It presents some of the challenges that the NPS staff encounter in plant propagation, as well as some of the techniques they use to keep propagation success rates high. The game illustrates that it is impossible for people to entirely control the propagation process. Some cards in the compost pile describe things that can be controlled (how much water plants get, for example) but some describe things that cannot be controlled (a fox carcass rots and fertilizes a native plant community or a big storm wipes out the plants). Students find that the scores in Return of the Wild! fluctuate as these scenarios are encountered.

### **TIME**

50 minutes

30 minutes for preparation

### **MATERIALS**

- ▶ Return of the Wild! board games (provided by NPS)
- ▶ Discussion questions
- ▶ Score sheet

## Lesson

### **Pass Out Games - 5 minutes**

Park staff divide the class into groups of 2 to 5 students and pass out the game boards and pieces. They explain that the students are to begin playing the game as soon as they receive a board and pieces. Students start by drawing ten cards each, moving along the board, and following the instructions on the cards they pick up along the way. If they begin with BONUS cards, they can draw extra cards immediately.

**Playing the Game - 15 minutes**

Students play as much of the game as possible in fifteen minutes.

**Scoring - 10 minutes**

Park staff stop the games, pass out the score sheets, and walk the students through the scoring procedure.

**Discussion - 15 minutes**

Once scores are tallied, park staff facilitate a group discussion:

- ▶ Based on the scoring procedure, what is valued most in this game?  
Diversity.
- ▶ What types of diversity are valued? Diversity of species and genetic diversity within a species represented by early-season, mid-season, and late-season germinators.
- ▶ Why is it important to have early-season, mid-season, and late-season germinators within a species? So the species can better survive environmental disturbances. For example, early spring germinators may not survive an early spring frost but mid-spring and late-spring germinators probably will.

The key concept in successful ecological restoration with native plants is *natural selection*, not *cultural selection*. All aspects of the native plant nursery cycle emphasize the maintenance of genetic diversity; seeds are collected from many different plants, and both small (late-season germinators) and robust (early-season germinators) are transplanted.

**Journal**

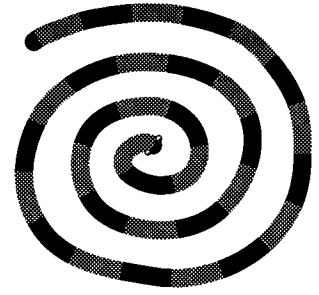
Park staff pass out the discussion questions for students to complete as homework.

**Closing - 5 minutes**

Park staff explain that during the field visit to Golden Gate National Recreation Area, students will work alongside NPS staff, propagating plants and assisting with nursery operations. They remind students to dress in layers and wear clothing that they can get dirty (sneakers, no white shoes or pants), and to bring water and a snack.

# Return of the Wild!

## Discussion Questions



1. Describe two actions or events that increased your final number of native plants and two actions or events that decreased your final number of native plants.

---

---

---

---

---

---

2. Describe a strategy that would give you the highest score at the end of the game.

---

---

---

---

---

---

3. How is your strategy related to the plant propagation goals of the native plant nursery at the Presidio?

---

---

---

---

---

---

# El Regreso de la Naturaleza



1. Describa dos acciones o eventos que aumentan su cantidad final de plantas nativas y dos acciones o eventos que disminuyen su cantidad final de plantas nativas.

---

---

---

---

---

---

2. Describa una estrategia que le daría la puntuación más alta al final del partido.

---

---

---

---

---

---

3. ¿Cómo se relaciona su estrategia con las metas de propagación de plantas nativas del vivero del Presidio?

---

---

---

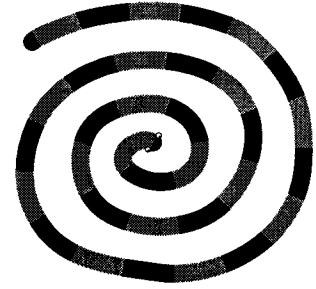
---

---

---

---

## 回歸野外！ 討論問題



1. 說明兩個可以增加本地植物的數目的行動或活動，和兩個可以減少本地植物的數目的行動或活動。

---

---

---

---

---

---

2. 說明你可以在遊戲最後取得最高分數的方法。

---

---

---

---

---

---

3. 你的方法，與 Presidio的本地植物苗圃的繁殖目標有什麼關係？

---

---

---

---

---

---

# Return of the Wild! Score Sheet

## INSTRUCTIONS:

- Check the boxes and circle the germination times that correspond to the plant cards in your hand. Give yourself one point for each plant you have checked.
- If you have all the plants in a community, check the community box. Give yourself one point for each community you have checked.
- If you have all three germination times for any plant, give yourself an additional 10 points for that plant. Total your points at bottom.

### ☐ FOREDUNE COMMUNITY

- |  |       |     |      |
|--|-------|-----|------|
| <input type="checkbox"/> Morning Glory       | early | mid | late |
| <input type="checkbox"/> Yellow Sand Verbena | early | mid | late |



### ☐ RIPARIAN COMMUNITY

- |                                  |       |     |      |
|----------------------------------|-------|-----|------|
| <input type="checkbox"/> Bulrush | early | mid | late |
|----------------------------------|-------|-----|------|

### ☐ DUNE SCRUB COMMUNITY

- |   |       |     |      |
|---|-------|-----|------|
| <input type="checkbox"/> Pearly Everlasting   | early | mid | late |
| <input type="checkbox"/> Coyote Brush         | early | mid | late |
| <input type="checkbox"/> Mock Heather         | early | mid | late |
| <input type="checkbox"/> Sticky Monkey Flower | early | mid | late |

### ☐ SERPENTINE BLUFF COMMUNITY

- |   |       |     |      |
|---|-------|-----|------|
| <input type="checkbox"/> San Francisco Wallflower | early | mid | late |
| <input type="checkbox"/> Coast Buckwheat          | early | mid | late |
| <input type="checkbox"/> Yarrow                   | early | mid | late |

### ☐ SERPENTINE GRASSLAND COMMUNITY

- |   |       |     |      |
|---|-------|-----|------|
| <input type="checkbox"/> California Poppy | early | mid | late |
| <input type="checkbox"/> Soap Plant       | early | mid | late |

number of different plants \_\_\_\_\_

number of communities \_\_\_\_\_

number of diversity points \_\_\_\_\_

TOTAL POINTS \_\_\_\_\_

# ○ Plant Propagation

## **SUMMARY**

Students work with nursery staff on plant propagation and other nursery operations. They gain an understanding of how nursery work fits into the restoration cycle. Students learn that a primary goal of the Presidio Native Plant Nursery is to increase genetic and species diversity of plants growing within GGNRA. Students who visit the nursery gain an appreciation for the vegetation that once thrived in the Bay Area and understand how our local ecosystem benefits from diversity. The class also knows that their work is crucial to park restoration, and that they are welcome to return to the nursery as a volunteer.

## **TIME**

2.5 hours

45 minutes for preparation

## **MATERIALS**

- Pots
- Propagation tags
- Plant information cards
- Demonstration plants
- Colored pencils
- Paper
- Calculators
- Whiteboards or flip charts (2)
- Markers
- Scrub brushes
- Microscope binder
- Specimen dishes
- Specimens for microscope station

## ⊕ Program

### **Arrival - 5 minutes**

Students put personal belongings into the coat closet and gather at nursery entrance.

### **Welcome - 5 minutes**

Park staff welcome the students and explain the nursery guidelines. Students divide into 4 groups.

### **Stations - 30 minutes each station x 4 stations = 2 hours**

Students cycle through 4 stations with nursery staff (see station instructions below).

**Clean up - 10 minutes**

Staff and students clean up the stations.

**Closing circle - 10 minutes**

Students and staff form a circle. Students share a question from their journals, ask a new question, or tell something they learned during the day. Park staff thank the students for their work.

---

**Station Guidelines****STATION 1 - TRANSPLANTING****Procedures:**

- ▶ Park staff introduce the species the students will be transplanting.
- ▶ Park staff place the rack of seedlings in the center of the table and ask the students which plants seem best fit for transplanting; it is likely that students will choose the largest plants as the most vital. Park staff ask students to think back to the Return of the Wild! board game they played in the pre-visit lesson. Why would they want to transplant seedlings of various sizes? Park staff help the students understand that to promote genetic diversity they should transplant seedlings of various sizes, because the size of a seedling is an indicator of when its seed germinated, not its health. (Propagating a set of plants with a variety of germination rates will allow the species to cope with a larger range of climatic conditions. For instance, if San Francisco were to experience an especially cold winter month, the plants that germinate during that month are likely to freeze to death. However, if the plant community in the area includes early-season, mid-season and late-season germinators, the species is likely to survive the atypical weather conditions.)
- ▶ Park staff give a careful transplanting demonstration, followed by a demonstration by one of the students. Without a patient introduction to the process, the students may focus on finishing as many transplants as they can and disregard the quality of the work. During the transplanting, individual students sterilize pots, get more plants from the greenhouse, tag the finished transplants, and get soil.
- ▶ During transplanting students and staff may discuss previous experiences they have had working with plants, other volunteer work they have done, or what

plans they have for the future. Staff can also use the time to help students imagine the GGNRA landscape that they are helping to create—one that is richer each year with indigenous plant growth.

## **STATION 2 - DEMONSTRATION GARDEN**

### **Procedures:**

- ▶ The demonstration garden is a simulation of the plant communities that historically covered a large part of the Presidio of San Francisco and are now found only in small patches along the coastline and throughout GGNRA.
- ▶ Park staff take a few minutes to introduce the station. They point out the diversity of species in the demonstration garden and the lack of invasive behavior among native plants. Students look at a small section of the demonstration garden. Is there more or less plant diversity in the small section as in other areas around the nursery? Why don't the native plants overrun each other? Students compare the demonstration garden with a less diverse community in another area of the nursery. What is a monoculture? If you depended on the land for food and medicine, which hillside would you rather live near? How does the biodiversity of plants benefit animal populations? Are all of the plants in bloom? Are some of the plants in seed? How is it beneficial to insects and other animals to have a variety of plants blooming at different times of the year? Students discuss plant adaptation. The shorter, lighter-colored plants are generally found in the sunny, windy foredune community (represented at the bottom of hill). They compare this community with the backdune community midway up the hill and the oak woodland community at the top of the hill.
- ▶ Nursery staff may assign the group to a planting or weeding project, but the most common student activity in the demonstration garden is plant observation and drawing. Park staff distribute a plant card, a blank piece of paper, and colored pencils to each student. Students take 10 to 15 minutes to locate the plant on their card and represent it in some way on their paper. They can draw it or write a poem or descriptive paragraph about it. They should also study the plant card and prepare a one-minute presentation about the plant. During the last 5 to 10 minutes of the station, students share their work with each other. Did students observe many different plants? What types of variations are there between individuals of the same species?

## STATION 3 - SEED CLEANING

### Procedures:

- ▶ Park staff explain to the students that in the park no more than 5 percent of any plant's seeds are collected, and seeds are collected from at least 10 individual plants per species. By propagating seeds collected from a variety of plants within a species, genetic diversity is maintained within GGNRA. High genetic diversity helps ensure that the species will thrive when faced with a variety of environmental pressures (climate shifts, diseases, predators, etc.).
- ▶ Park staff demonstrate the appropriate seed cleaning technique.
- ▶ During seed cleaning, students and staff may discuss these seed-related questions:
  - What are some of the different ways that seeds travel?  
(airborne, in feces, floating in water, stuck to animals' fur)
  - How do you think the seeds we are working with today travel when they are in nature?
  - Are you removing a dried fruit exterior, a flying mechanism, or a sharp shell?
  - Does this seed remind you of any others you have seen?
- ▶ During the last ten minutes of the station, students work in pairs on the math problem described below.

### Group Math Problem:

Park staff pose the following question and ask students what information they need to find the answer. As they call out the information they need (how big is the restoration site? how far apart are the plants spaced?, etc.), a volunteer writes the information on the whiteboard. If necessary, the group can draw a diagram. Students create an equation to calculate the answer (the equation should come from the students, NOT from the park staff).

**Question:** You will be planting a foredune restoration site at Crissy Field. The length of the restoration site is 50 feet and the width is 130 feet. (Most sites are not a perfect rectangle, but instead of using calculus to determine the actual area, we choose the closest estimates of length and width.) The amount of space required by each plant in a restoration site depends on the habitat: Fore dune plants are spaced 3.5 feet apart; serpentine plants are spaced 2 feet apart, transitional and backdune plants are spaced 3 feet apart. How many plants will be needed for this particular restoration area?

**Sample Problem-solving Method:** (Students may reach the answer in a variety of ways; park staff will let them follow their instincts.)

Calculate the area needed by each plant. Fore-dune plants are placed 3.5 feet apart, so each plant requires 12.25 square feet of space ( $3.5 \times 3.5 = 12.25$ ).

Determine the area of the site by multiplying the length times the width ( $50 \times 130 = 6,500$ ).

Calculate the number of plants needed by dividing the area of the restoration site by the area required for each plant ( $6500 \div 12.25 = 531$ )

**Solution:** 531 plants are needed.

#### STATION 4 - POT WASHING/MICROSCOPES

##### Procedures:

- ▶ Park staff explain to the students that they will clean and sterilize nursery containers, and then use microscopes to study the pathogens that make this cleaning and sterilizing a vital step in successful nursery operations. They discuss the importance of using bleach when cleaning pots. Students start thinking about the relationship of pot washing and disease and the relationship of disease and genetic diversity.
- ▶ Students spend the first portion of the station at the pot-washing sinks. Park staff assign each student a task: disassembling pots and racks, washing, rinsing, sterilizing, inspecting, and storing clean pots. After several minutes, students switch tasks.
- ▶ After approximately ten minutes of pot washing, the group moves to the microscope stations. Students should be careful of insects with stingers and of the hot light bulbs on the microscopes (the top light bulbs are the hottest). Students use the microscopes to examine the different diseases and insects. They match the pictures from the Microscopes binder with the specimens.
- ▶ Students discuss the relationship of genetic diversity to a species' ability to survive disease. (Some individuals in a species are more resistant to disease than others, so a diverse population has a better chance of surviving any given pathogen.)

- ▶ During the last five minutes of the station, students work together on the math problem described below.

**Group Math Problem:**

Park staff pose the following question and ask students what information they need to find the answer. As they call out the information they need (percentage of seeds that germinate and survive), a volunteer writes the information on the whiteboard. If necessary, the group can draw a diagram. Students create an equation to calculate the answer (the equation should come from the students, NOT from the park staff).

**Question:** Of the 531 plants needed for a restoration site, 80 are Sand Verbena. If the survival rate for Sand Verbena is 65 percent, how many seeds need to be propagated at the nursery to meet the goal for this species?

Note: The survival rate is the percent of propagated plants that survive to be transplanted into the field. This percentage varies for each plant species and is determined by a germination test in which 100 seeds are sown and the sprouts that survive are counted. The average survival rate for plants grown in the park's native plant nurseries is about 60 percent.

**Sample Problem-solving Method:** (Students may reach the answer in a variety of ways; park staff will let them follow their instincts.)

Let  $n$  = number of plants to propagate,  $r$  = survival rate,  
and  $z$  = number of plants needed for restoration site.

The number of plants propagated times the survival rate for the species equals the number of plants required for the restoration site ( $n \times r = z$ ).

$$n \times 65\% = 80 \qquad n = 80 \div 65\% \qquad n = 123$$

**Solution:** You need to propagate 123 seeds in order to have 80 of them sprout and survive for planting into the restoration site.

## ● Seed Experiments Program

### **SUMMARY**

Students germinate seeds, compare plant growth and health, introduce variations on soil pH, test soil, and gather and analyze data on prime conditions for plant growth.

### **TIME**

three 50-minute class periods

5 minutes each day for observing/recording for 3 weeks

60 minutes for preparation

### **MATERIALS**

- Seeds
- Paper towels
- Pots
- Substances to change soil conditions, such as baking soda, vinegar, fertilizer, sand, clay, silt, etc.
- Observation Worksheet/Parts 1, 2, 3, and 4
- Petri dish or plastic bag
- Soil
- Soil test kits (provided by NPS)

## ○ Program

**Part I** - one 50-minute class period plus 5 minutes for observation/recording each day for the next week

- Teacher gives each student paper towels, petri dish or plastic bag, and two seeds. Yarrow, poppy and other California native plant seeds are available at local nurseries. Lima beans can also be used.
- Teacher distributes Observation Worksheet/Part 1 and asks students to make observations about their seeds' appearance.
- Students put their seeds between the paper towels, insert them into the petri dish or bag, and water them (a clean spray bottle works well). Towels should be moist, not wet; standing water encourages fungi. Students record their names on their petri dishes or bags.
- Students water seeds for one week (or longer if necessary) until most of the seeds germinate. During this time, students make daily observations and record important information on Observation Worksheet/Part 1.

**Part 2** - one 50-minute class period plus 5 minutes for observation/recording each day for the next week

- At the end of the week (or when most of the seeds have germinated), the students compile their information on germination rates and complete the first part of Observation Worksheet/Part 2.
- In groups of two or three, students choose the types of variations they will introduce into their seedlings' soil medium. Possibilities include changing pH (by adding acidic or basic substances such as vinegar and baking soda), altering soil composition (sand/clay/silt ratio), using various fertilizers, and using store bought soil mix versus dirt from the yard. Altering soil conditions demonstrates the importance of soil composition and the effects of contaminants in soils. Students leave the soil of one or more seedlings unaltered to serve as the control group for their experiment.
- Students transplant seedlings into the altered soil.
- Using soil testing kits, students test soil pH, nitrogen, phosphorous and potassium levels. Students then begin Observation Worksheet/Part 3.

**Part 3** - one 50-minute class period plus 5 minutes for observation/recording each day for the next week

- Students monitor plant growth and health for one week and record their observations on Observation Worksheet/Part 3.
- At the end of the week, students compile their data and complete Observation Worksheet/Part 4.

# Observation Worksheet

## Part 1



(Answer before sowing seeds)

1. What is the common name of your seed species?

---

2. Describe the condition of your seeds. What do the seed coats look like? Is there any visible damage? Are the seeds robust or withered? etc.

---



---



---



---

3. Predict the number of days it will take for your seeds to germinate.

---

4. Monitor daily changes below. Note the day of seed germination.

	Date	Time	Observation
Seed A			
Seed B			

# Observation Worksheet

## Part 2



(Complete one week after sowing seeds)

1. How long did it take for your seeds to germinate?

Seed A: \_\_\_\_\_ days      Seed B: \_\_\_\_\_ days

2. Did your seed take a longer or shorter time to germinate compared to other seeds in your classroom?

(circle one)    Longer    Shorter

3. What is the average time that it took for all the seeds in your classroom to germinate?

---

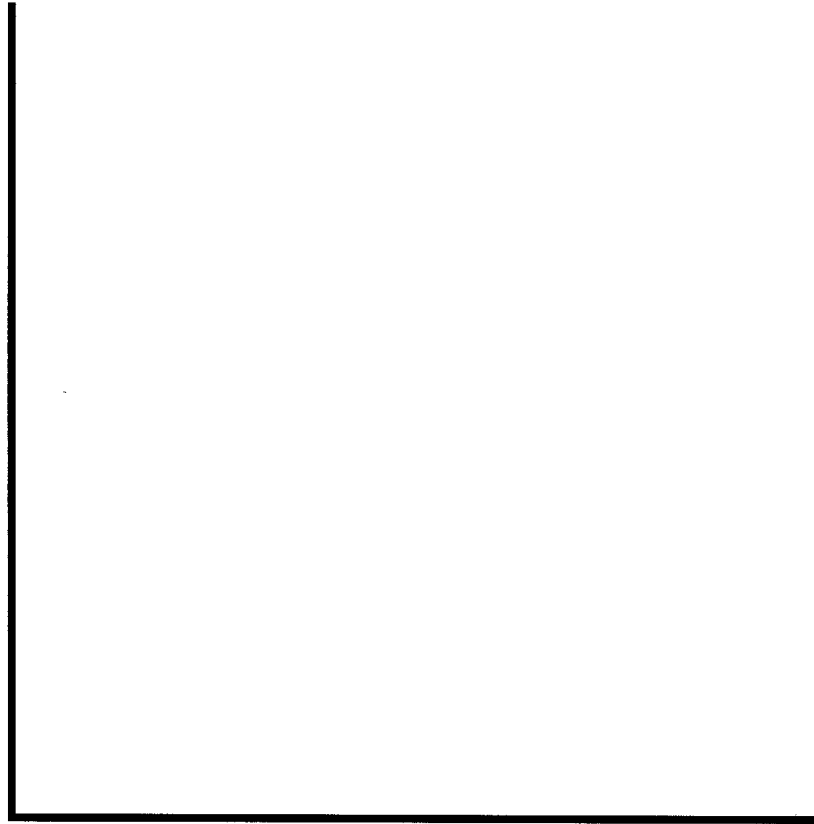
Sum of germination days  $\div$  Number of seeds =  
Average days of germination

4. What was the germination rate (percentage of seeds sown that germinated) in your classroom?

---

Number of germinated seeds  $\div$  Total number of seeds  $\times$  100 =  
% germination rate

5. Graph the time it took for all the seeds to germinate.  
Label both axes.



6. What are some of the reasons why the seeds germinated on different days?

---

---

---

---

---

---

# Observation Worksheet

## Part 3



(Complete immediately after treating soil)

1. How was your soil treated?

Seedling A	Seedling B

2. Measure the pH, nitrogen, phosphorous, and potassium levels of the soil and record below:

Seedling A: pH \_\_\_\_\_ nitrogen \_\_\_\_\_

phosphorous \_\_\_\_\_ potassium \_\_\_\_\_

Seedling B: pH \_\_\_\_\_ nitrogen \_\_\_\_\_

phosphorous \_\_\_\_\_ potassium \_\_\_\_\_

3. Predict the growth of the plant in altered soil (experimental plant) compared to the control plants.

---

---

---

---

---

4. Monitor daily changes below:

	Date	Time	Observation
Seed A			
Seed B			

# Observation Worksheet

## Part 4



(Complete one week after treating soil)

1. How has your experimental plant grown in comparison with your control plant?

---

---

---

---

---

2. How has your plant grown in comparison with other plants in your classroom?

---

---

---

---

---

3. How does your actual plant growth compare to your prediction from Observation Worksheet/Part 2?

---

---

---

---

---

4. What are the most favorable conditions for plant growth?

---

---

---

5. What are the least favorable conditions for plant growth?

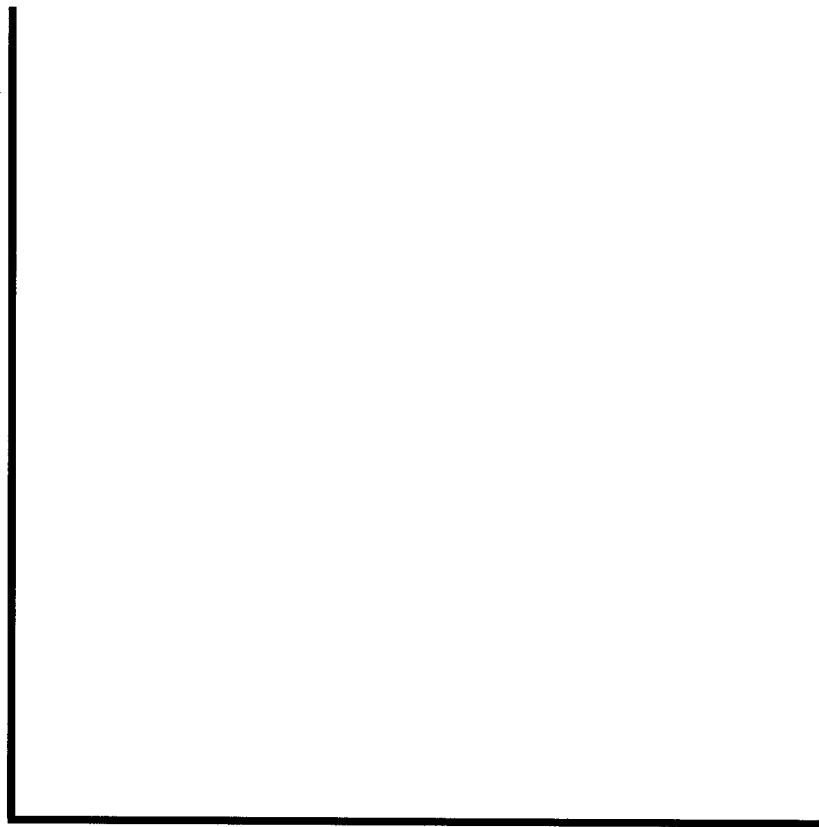
---

---

---

---

6. Create a graph that compares plant growth under varying conditions. Include all details that you feel are important. Label both axes.



7. How do contaminants in soil affect genetic diversity?

---

---

---

---

# Hoja de Trabajo para Observaciones - Parte 1



(Conteste antes de sembrar las semillas)

1. ¿Cuál es el nombre común de su especie de semillas?

---

2. Describa la condición de sus semillas. ¿Cómo luce la cubierta o cáscara de las semillas? ¿Hay algún daño visible? ¿Están robustas o marchitas las semillas? Etc..

---



---



---

3. ¿Prediga el número de días que se tardará en germinar su semilla?

---

4. Supervise los cambios diarios a continuación. Anote el día en que germinó la semilla.

	Fecha	Hora	Observaciones
Semilla A			
Semilla B			

# Hoja de Trabajo para Observaciones - Parte 2



(Complétela una semana después de haber sembrado sus semillas)

1. ¿Cuánto tiempo se tardó en germinar su semilla?

Semilla A: \_\_\_\_\_ # días

Semilla B: \_\_\_\_\_ # días

2. ¿Se tardó su semilla más o menos tiempo en germinar en comparación con las semillas de otras personas en su salón?

\_\_\_ Más Tiempo

\_\_\_ Menos Tiempo

3. ¿Cuál fue el tiempo promedio que tardaron en germinar las semillas en su clase?

---

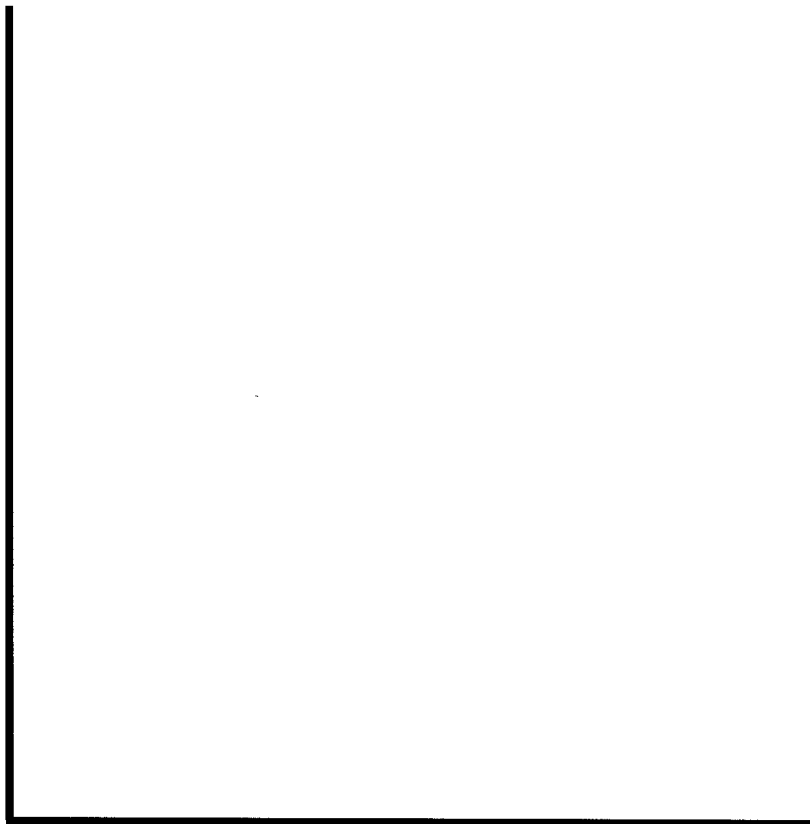
Suma de días que tardaron en germinar ÷ cantidad de semillas =  
promedio de días que tardaron en germinar

4. ¿Cuál fue la tasa de germinación (porcentaje de semillas sembradas que germinaron) en su salón de clases?

---

Numero de semillas que han germinado ÷ cantidad de semillas × 100 =  
% la tasa de germinación

5. Dibuje una gráfica del tiempo que se tardaron en germinar las semillas. Rotule ambos ejes.



6. ¿Cuáles son algunas de las razones por las cuales las semillas germinaron en días diferentes?

---

---

---

---

---

---

# Hoja de Trabajo para Observaciones - Parte 3



(Complétela inmediatamente después de haber acondicionado la tierra)

1. ¿Qué tratamiento le aplicó a la tierra?

Semilla A	Semilla B

2. Mida los niveles de pH, nitrógeno, fósforo y potasio de la tierra y anótelos a continuación.

Semilla A: pH \_\_\_\_\_ Nitrógeno \_\_\_\_\_

Fósforo \_\_\_\_\_ Potasio \_\_\_\_\_

Semilla B: pH \_\_\_\_\_ Nitrógeno \_\_\_\_\_

Fósforo \_\_\_\_\_ Potasio \_\_\_\_\_

3. Prediga el crecimiento de la planta en terreno alterado (planta experimental) comparado con la planta control


4. Supervise los cambios diarios a continuación:

	Fecha	Tiempo	Observaciones
Semilla A			
Semilla B			

# Hoja de Trabajo para Observaciones - Parte 4



(Complétela una semana después de haber acondicionado la tierra)

1. ¿Cómo ha crecido su planta experimental en comparación con su planta control?

---

---

---

---

---

2. ¿Cómo ha crecido su planta en comparación con otras plantas de su salón de clases?

---

---

---

---

---

3. ¿Cómo compara el crecimiento de su planta al presente con su predicción de la hoja de trabajo para observaciones - Parte 2?

---

---

---

---

---

4. ¿Cuáles son las condiciones más favorables para el crecimiento de la planta?

---

---

---

5. ¿Cuáles son las condiciones menos favorables para el crecimiento de la planta?

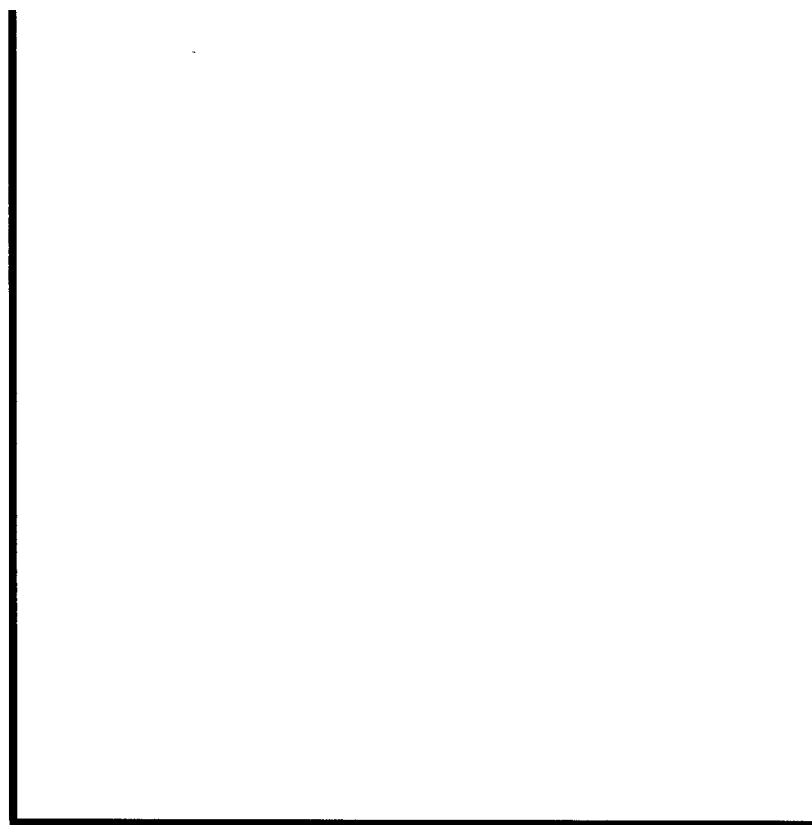
---

---

---

---

6. Dibuje una gráfica que compare el crecimiento de las plantas bajo condiciones variables. Incluya todos los detalles que usted piensa son importantes. Rotule ambos ejes.



7. ¿Cómo afecta la diversidad genética los contaminantes que hay en el terreno?

---

---

---

# 觀察記錄表

## 第一部份

(在播種以前回答)



1. 你的種籽品種俗名是什麼？

---

2. 說明你的種籽的狀況。種皮看起來如何，是否看得到任何損傷，種籽是健康還是枯萎的？等等。

---



---



---



---

3. 預測你的種籽需要多少天才會發芽。

---

4. 在下面記下每天觀察的變化。記下種籽哪一天發的芽。

	日期	時間	觀察結果
種籽 A			
種籽 B			

# 觀察記錄表

## 第二部份



(在播種之後第二週填寫)

1. 你的種籽花了幾天的時間發芽？

種籽 A: \_\_\_\_\_ 天      種籽 B: \_\_\_\_\_ 天

2. 你的種籽和課堂上的其他種籽相比，發芽所花的時間比較長還是比較短？

(圈選一個)    長    短

3. 課堂上所有的種籽發芽的平均時間是多久？

---

發芽的總天數 ÷ 種籽數 =

平均的發芽天數

4. 課堂上的發芽率(播種的種籽發芽的百分比)如何？

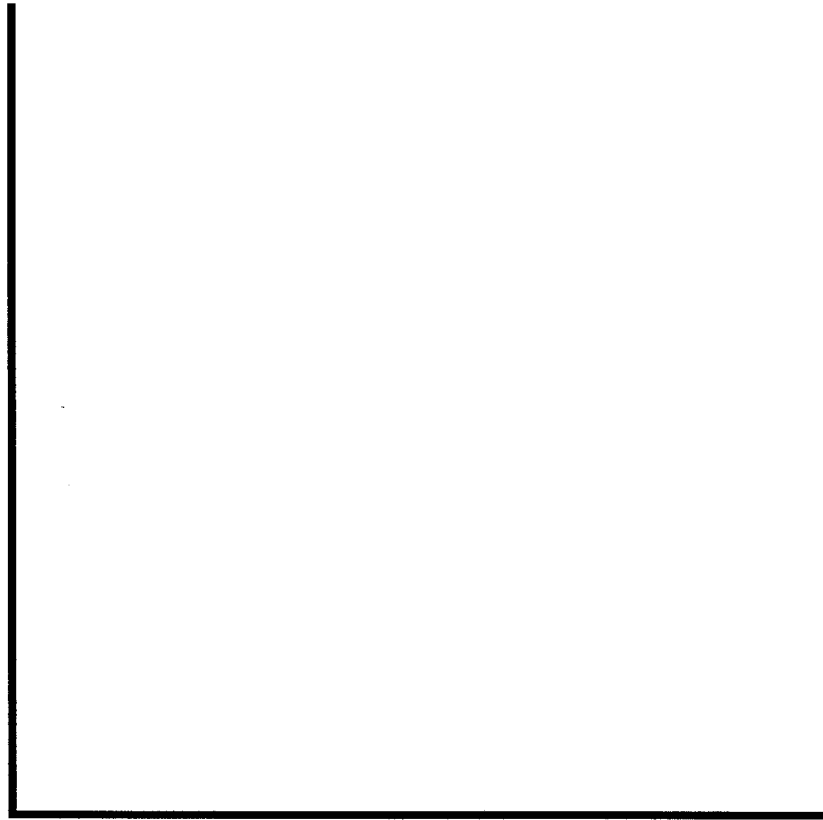
---

發芽的種籽數 ÷ 種籽的總數 × 100 =

% 發芽率

5. 用圖表表示出所有的種籽發芽需要的時間。

標出 X和 Y兩個軸線。



6. 種籽在不同天發芽的原因有哪些？

---

---

---

---

---

---

# 觀察記錄表

## 第三部份



(在測試土壤之後馬上填寫)

1. 你用什麼方法測試土壤？

苗木 A	苗木 B

2. 測量土壤的酸鹼值、氮、磷和鉀的濃度，然後記在下面：

苗木 A:      酸鹼值 \_\_\_\_\_ 氮 \_\_\_\_\_

                 磷 \_\_\_\_\_ 鉀 \_\_\_\_\_

苗木 B:      酸鹼值 \_\_\_\_\_ 氮 \_\_\_\_\_

                 磷 \_\_\_\_\_ 鉀 \_\_\_\_\_

3. 預測更動過的土壤中的植物（實驗植物）和對照植物比較之下的生長情況。

---



---



---



---



---

4. 在下面記下每天觀察的變化:

	日期	時間	觀察結果
種籽 A			
種籽 B			

# 觀察記錄表

## 第四部份

(在測試土壤之後第二週)



1. 你的實驗植物和對照植物比較之下的生長情況如何？

---

---

---

---

---

2. 你的植物和課堂上其他植物比較之下的生長情況如何？

---

---

---

---

---

3. 與觀察練習紙／第二部份所預測的比較之下，你的植物實際生長情況如何？

---

---

---

---

---

4. 對植物的生長最有利的條件是什麼？

---

---

---

5. 對植物的生長最不利的條件是什麼？

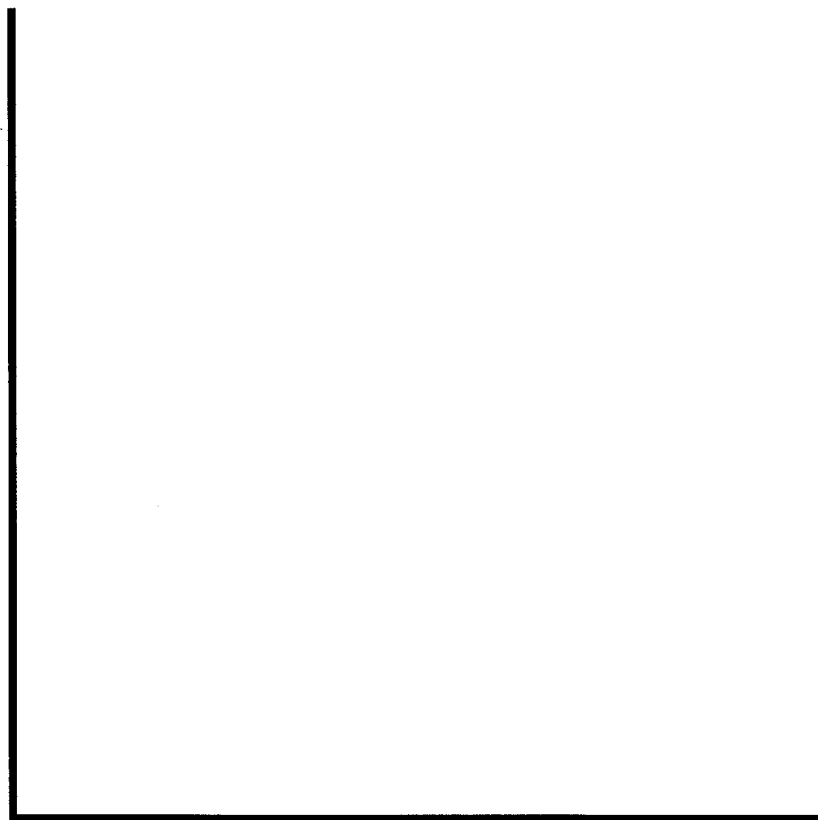
---

---

---

---

6. 繪出一個圖表，比較不同狀況下植物的生長情況。包括所有你認為重要的細節。  
標出X和Y兩個軸線。



7. 土壤被污染之後會對遺傳多元化產生什麼影響？

---

---

---

---

---

---

# Rubric

## Plant Propagation

### Science (Diversity)

*Needs Improvement:* Students do not understand importance of diversity or how genetic and species diversity can be maintained.

*Good:* Students understand the importance of diversity but don't fully understand how genetic and species diversity can be maintained.

*Excellent:* Students understand the importance of diversity and can explain several ways genetic and species diversity can be maintained.

### Math (Algebra)

*Needs Improvement:* Students cannot create equations to answer questions about propagation needs at the nursery without extensive help from the facilitator.

*Good:* Students can create equations to answer questions about propagation needs at the nursery but need prompting from the facilitator.

*Excellent:* Students can create equations to answer questions about propagation needs at the nursery with no help from the facilitator.

### Life Skills (Cooperative Learning)

*Needs Improvement:* Students show incomplete interaction, often ignore comments, group efforts are easily sidetracked, some members uninvolved in group.

*Good:* More than half the members are actively involved, rarely are comments ignored, rarely stray from topic.

*Excellent:* All students participate equally, actively listen to one another, show respect for ideas, stay on task.